



**[4910-13]**

**DEPARTMENT OF TRANSPORTATION**

**Federal Aviation Administration**

**14 CFR Part 25**

**[Docket No. FAA-2016-6137; Notice No. 25-16-05-SC]**

**Special Conditions:** The Boeing Company Model 787-10 Airplane; Aeroelastic Stability Requirements, Flaps-Up Vertical Modal-Suppression System.

**AGENCY:** Federal Aviation Administration (FAA), DOT.

**ACTION:** Notice of proposed special conditions.

**SUMMARY:** This action proposes special conditions for the Boeing Company (Boeing) Model 787-10 airplane. This airplane will have a novel or unusual design feature when compared to the state of technology envisioned in the airworthiness standards for transport-category airplanes. This design feature is a flaps-up vertical modal-suppression system. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for this design feature. These proposed special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

**DATES:** Send your comments on or before **[INSERT DATE 45 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

**ADDRESSES:** Send comments identified by docket number FAA-2016-6137 using any of the following methods:

- *Federal eRegulations Portal:* Go to <http://www.regulations.gov/> and follow the online instructions for sending your comments electronically.

- *Mail:* Send comments to Docket Operations, M-30, U.S. Department of Transportation (DOT), 1200 New Jersey Avenue, SE., Room W12-140, West Building Ground Floor, Washington, DC, 20590-0001.
- *Hand Delivery or Courier:* Take comments to Docket Operations in Room W12-140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.
- *Fax:* Fax comments to Docket Operations at 202-493-2251.

*Privacy:* The FAA will post all comments it receives, without change, to <http://www.regulations.gov/>, including any personal information the commenter provides. Using the search function of the docket Web site, anyone can find and read the electronic form of all comments received into any FAA docket, including the name of the individual sending the comment (or signing the comment for an association, business, labor union, etc.). DOT's complete Privacy Act Statement can be found in the **Federal Register** published on April 11, 2000 (65 FR 19477-19478), as well as at <http://DocketsInfo.dot.gov/>.

*Docket:* Background documents or comments received may be read at <http://www.regulations.gov/> at any time. Follow the online instructions for accessing the docket or go to Docket Operations in Room W12-140 of the West Building Ground Floor at 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

**FOR FURTHER INFORMATION CONTACT:** Wael Nour, FAA, Airframe and Cabin Safety Branch, ANM-115, Transport Airplane Directorate, Aircraft Certification Service, 1601 Lind

Avenue SW., Renton, Washington, 98057-3356; telephone 425-227-2143; facsimile 425-227-1320.

## **SUPPLEMENTARY INFORMATION:**

### **Comments Invited**

We invite interested people to take part in this rulemaking by sending written comments, data, or views. The most helpful comments reference a specific portion of the special conditions, explain the reason for any recommended change, and include supporting data.

We will consider all comments we receive by the closing date for comments. We may change these special conditions based on the comments we receive.

### **Background**

On July 30, 2013, Boeing applied for an amendment to type certificate no. T00021SE to include the new Model 787-10 airplane. This airplane is a stretched-fuselage derivative of the 787-9, currently approved under type certificate no. T00021SE, with maximum single-class seating capacity of 440 passengers. The 787-10 has a maximum takeoff weight of 560,000 lbs and is powered by two General Electric GENx-1B/P2 or Rolls-Royce Trent 1000 engines.

### **Type Certification Basis**

Under the provisions of Title 14, Code of Federal Regulations (14 CFR) 21.101, Boeing must show that the Model 787-10 airplane meets the applicable provisions of the regulations listed in type certificate no. T00021SE or the applicable regulations in effect on the date of application for the change, except for earlier amendments as agreed upon by the FAA.

In addition, the certification basis includes other regulations, special conditions, and exemptions that are not relevant to these proposed special conditions. Type certificate no.

T00021SE will be updated to include a complete description of the certification basis for this airplane model.

If the Administrator finds that the applicable airworthiness regulations (i.e., 14 CFR part 25) do not contain adequate or appropriate safety standards for the Model 787-10 airplane because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same or similar novel or unusual design feature, or should any other model already included on the same type certificate be modified to incorporate the same novel or unusual design feature, these special conditions would also apply to the other model under § 21.101.

In addition to the applicable airworthiness regulations and special conditions, the Model 787-10 airplane must comply with the fuel-vent and exhaust-emission requirements of 14 CFR part 34, and the noise-certification requirements of 14 CFR part 36.

The FAA issues special conditions, as defined in 14 CFR 11.19, in accordance with § 11.38, and they become part of the type certification basis under § 21.101.

### **Novel or Unusual Design Features**

The Model 787-10 airplane will incorporate the following novel or unusual design features:

A flaps-up vertical modal suppression system.

### **Discussion**

The Boeing Model 787-10 will add a new flaps-up vertical modal-suppression (F0VMS) system to the Normal mode of the primary flight-control system (PFCS). The F0VMS system is

needed to satisfy the flutter-damping margin requirements of § 25.629 and the means-of-compliance provisions in advisory circular (AC) 25.629-1B. This system will be used in lieu of typical methods of improving the flutter characteristics of an airplane, such as increasing the torsional stiffness of the wing or adding wingtip ballast weights.

The F0VMS system is an active modal-suppression system that will provide additional damping to an already stable, but low-damped, 3Hz symmetric wing, nacelle, and body aeroelastic mode of the airplane. This feedback-control system will compensate for a flutter-damping margin deficiency of the airplane and maintain adequate damping margins to flutter. The F0VMS system accomplishes this by oscillating the elevators, and, when needed, the flaperons.

Because Boeing's flutter analysis shows that the 3Hz mode is stable and does not flutter, the F0VMS system is not an active flutter-suppression system, but, rather, a damping-augmentation system. At this time, the FAA is not prepared to accept an active flutter-suppression system that suppresses a divergent flutter mode in the operational or design envelope of the airplane.

This will be the first time an active modal-suppression system will be used to compensate for a flutter-damping margin deficiency for § 25.629 compliance, and the FAA intends to take a conservative approach in the technology's application. The FAA considers the use of this new active modal-suppression system for flutter compliance to be novel or unusual when compared to the technology envisioned in the current airworthiness standards. Consequently, special conditions are required in consideration of the effects of this new system on the aeroelastic stability of the airplane, both in the normal and failed state, to maintain the level of safety intended by § 25.629.

The stretched body of the 787-10 degrades the 3Hz symmetric wing, nacelle, and body aeroelastic mode relative to the 787-9. The 3Hz aeroelastic mode of the 787-10 airplane without the F0VMS system does not meet the damping margin criteria of AC 25.629-1B within the operational envelope, as well as the design envelope, of the airplane. The 3Hz mode is not predicted to flutter, but has a lack of adequate flutter-damping margin for the airplane. Boeing has determined that typical methods of improving the flutter characteristics of the airplane, such as increasing the torsional stiffness of the wing or adding wingtip ballast weights, do not meet their business objectives. Consequently, Boeing is adding a new F0VMS system to the Normal mode of the Model 787-10 airplane PFCS to satisfy the flutter-damping margin requirements of § 25.629, and means-of-compliance provisions contained in AC 25.629-1B. The F0VMS system will be active in certain parts of the flight envelope when the flaps are retracted. The F0VMS system is a feedback-control system that adds damping to the system's 3Hz mode by oscillating the elevators symmetrically. When the elevators are expected to be ineffective due to blowdown or other limitations, the flaperons are applied to augment or supplant elevator-control input. However, the flaperons are not as effective as the elevators in providing additional damping to the 3Hz mode.

The F0VMS system will be an integral part of the PFCS Normal mode and use existing hardware, including inertial and air-data sensors. As such, the F0VMS system is expected to be as reliable as the Normal mode itself. In other words, any failures that would cause a loss of the F0VMS function would also cause a loss of the Normal mode. FAA issue paper SA-17, "Command Signal Integrity," requires that the probability of an automatic change from Normal mode to a degraded mode of the PFCS should occur with a frequency less than  $10^{-7}$  per flight hour, irrespective of flight phase. This reliability is acceptable for the F0VMS system meeting

the flutter-damping margins of § 25.629 and AC 25.629-1B, and the requirements of these special conditions. The F0VMS function is only available in the PFCS Normal mode, and not available in the Secondary or Direct modes. However, the PFCS Secondary and Direct modes include a simplified modal-suppression function, which provides additional damping margin.

In addition to the Model 787-10 airplane needing the F0VMS functionality for flutter compliance, this functionality will also be used for active nacelle gust-load alleviation (NGLA), because the low damping exhibited by the 3Hz mode adversely affects nacelle gust loads. Therefore, the Boeing Model 787-9 airplane NGLA system will not need to be carried over to the Model 787-10 airplane.

These proposed special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

### **Applicability**

As discussed above, these special conditions are applicable to the Boeing Model 787-10 airplane. Should Boeing apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design feature, these special conditions would apply to that model as well.

### **Conclusion**

This action affects only certain novel or unusual design features on one model series of airplane. It is not a rule of general applicability.

### **List of Subjects in 14 CFR Part 25**

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

The authority citation for these special conditions is as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

## **The Proposed Special Conditions**

Accordingly, the Federal Aviation Administration (FAA) proposes the following special conditions as part of the type certification basis for Boeing Model 787-10 airplanes.

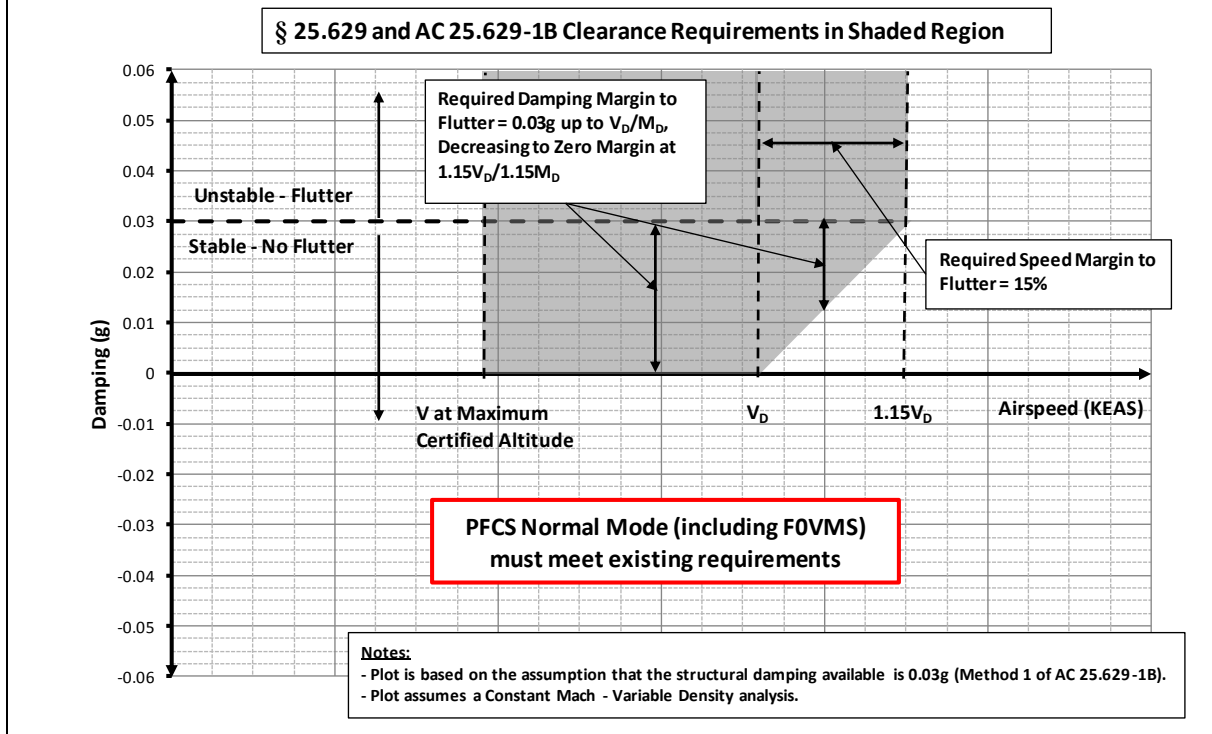
The following special conditions are proposed to address the aeroelastic stability of the 787-10 airplane with the F0VMS system as an integral part of the PFCS Normal mode:

### **Analytical Flutter-Clearance Requirements**

1. The airplane in the PFCS Normal mode (which includes F0VMS) must meet the nominal (no failures) flutter and aeroelastic stability requirements of § 25.629(b)(1), and the damping-margin criteria of AC 25.629-1B, Section 7.1.3.3. Figure 1, below, illustrates the Damping versus Airspeed plot.
  - a. The aeroservoelastic analysis must take into account the effect of the following items:
    - i. Significant structural and aerodynamic nonlinearities.
    - ii. Significant F0VMS nonlinearities, including control-surface rate and displacement saturation, and blowdown.
    - iii. The range of design maneuver load factors.
    - iv. Control surface freeplay.
    - v. Any other items that may affect the performance of the F0VMS system in maintaining adequate modal damping margins.

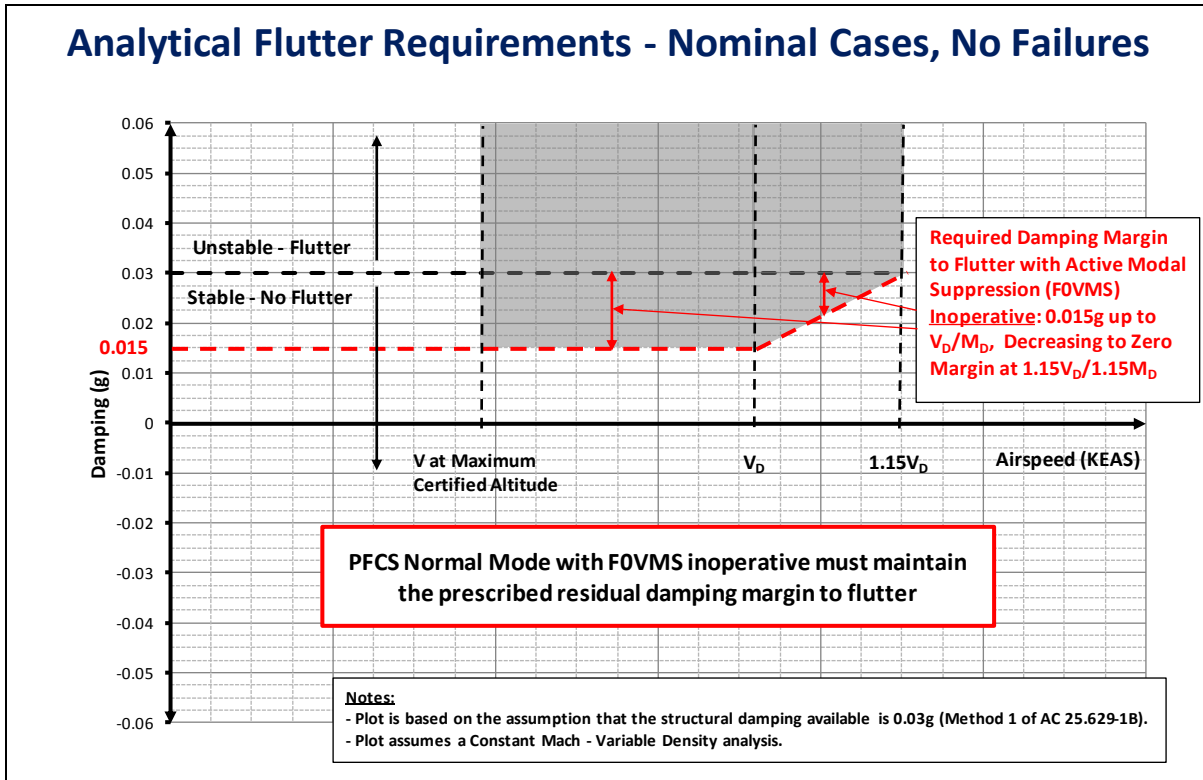


## Analytical Flutter Requirements - Nominal Cases, No Failures



**Figure 1: Damping vs. Airspeed; PFCS Normal mode, F0VMS system operative**

- The airplane in the PFCS Normal mode, but with the F0VMS system inoperative, must exhibit a damping margin to flutter of 0.015g within the  $V_D/M_D$  envelope, linearly decreasing (in KEAS) to zero damping margin to flutter at  $1.15 V_D / 1.15 M_D$ , limited to Mach 1.0. That is, the 3Hz mode should not cross the  $g=0.015$  line below  $V_D$ , or the  $g=0.03$  line below  $1.15 V_D$ , assuming the use of analysis Method 1 of AC 25.629-1B, Section 7.1.3.3. Figure 2, below, illustrates the Damping versus Airspeed plot.



**Figure 2: Damping vs. Airspeed; PFCS Normal mode, F0VMS system inoperative**

3. The airplane in the PFCS Normal mode (which includes F0VMS) must meet the fail-safe flutter and aeroelastic stability requirements of § 25.629(b)(2), and the damping-margin criteria of AC 25.629-1B, Section 7.1.3.5.
4. The airplane in the PFCS Secondary and Direct modes must meet the fail-safe flutter and aeroelastic-stability requirements of § 25.629(b)(2), and the damping-margin criteria of AC 25.629-1B, Section 7.1.3.5.

Issued in Renton, Washington, on September 9, 2016.

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